

Atty. Docket No. OPP030889US/PPW06-563DS
Serial No: 10/676,645

Remarks

Applicant and his representatives wish to thank Examiner Nadav for the careful consideration of the Amendment filed April 17, 2006 and the clear explanations in the Office Action dated January 19, 2006.

Claims 21, 25, 26 and 33 have been canceled. New Claim 35 has been added. Claims 6-7 and 9-20 have been previously canceled. Therefore, Claims 1-5, 8, 22-24, 27-32 and 34-35 are active in this application. No new matter is introduced by the present Amendment.

The present invention relates to a semiconductor device comprising:

- a) a via within an insulation layer over a semiconductor substrate;
- b) a barrier metal layer on a surface of the via;
- c) a metal line in the via over the barrier metal layer;
- d) a pad in a predetermined region of the metal line; and
- e) an alloy layer on an upper surface of the metal line, wherein a top surface of the alloy layer is coplanar with or lower than a top surface of the insulation layer, and the alloy layer comprises a metal of the metal line and a low melting point metal having a melting point less than or equal to 1000°C. (see Claim 1 above).

The cited references do not disclose or suggest, alone or taken together, a semiconductor device including an alloy layer on an upper surface of a metal line, comprising a metal of the metal line and a low melting point metal having a melting point less than or equal to 1000°C., where the alloy layer has a top surface that is coplanar with or lower than a top surface of the insulation layer. It is also believed that the cited references do not disclose or suggest a pad in a predetermined region of the metal line. Thus, the present claims are patentable over the cited references.

Atty. Docket No. OPP030889US/PPW06-563DS
Serial No: 10/676,645

The Rejection of Claims 1-5, 23, 26-38 and 30 under 35 U.S.C. § 102(e)

The rejection of Claims 1-5, 23, 26-28 and 30 under 35 U.S.C. 102(e) as being anticipated by Sekiguchi (U.S. Pat. Appl. Publ. No. 2002/0024142, hereinafter "Sekiguchi") is respectfully traversed.

The Office Action appears to characterize the disclosure of Sekiguchi using the terms recited in the present claims, rather than the terms disclosed by Sekiguchi. However, assuming *arguendo* that the characterization of Sekiguchi in the Office Action is reasonably accurate, the alloy layer 111/115 of Sekiguchi is not coplanar with or lower than a top surface of the insulation layer 101 (see, e.g., FIGS. 1A-1E of Sekiguchi). As a result, Sekiguchi does not anticipate the present Claims 1-5, 23, 26-28 and 30.

Thus, the rejection under 35 U.S.C. § 102(e) is not sustainable and should be withdrawn.

The Rejection of Claims 24-25 and 32 under 35 U.S.C. § 103(a)

The rejection of Claims 24-25 and 32 under 35 U.S.C. § 103(a) as being unpatentable over Sekiguchi is respectfully traversed.

Applicant's undersigned representative notes that the former Claim 25 is not a product-by-process claim. To clarify the record, Claim 25 did not recite the term "forming," although the Office Action indicates that it did (see p. 5, first full paragraph of the Office Action dated June 14, 2006). Applicant's undersigned representative agrees that the limitation recited in Claim 25 ("wherein the alloy comprises a reaction product of the metal line and the low melting point metal") recites a structure. A material can be characterized as a reaction product without requiring that the process of reacting be performed. For example, a claim that recites "a reaction product of a proton and a hydroxide ion" would read on water, and would not require one to form it by reacting a proton and a hydroxide ion. Grammatically, there is no verb in the recited limitation. It is not understood how one can read a verb (process) into the limitation.

However, regardless of the thickness of the barrier layer(s) disclosed by Sekiguchi (see p. 4, last full paragraph of the Office Action), Sekiguchi does not appear to teach, disclose or

Atty. Docket No. OPP030889US/PPW06-563DS
Serial No: 10/676,645

suggest an alloy layer (e.g., layers 111/115 in FIGS. 1A-1E of Sekiguchi) having a top surface that is coplanar with or lower than a top surface of the insulation layer 101. Given that layers 111/115 in FIGS. 1A-1E of Sekiguchi (and their equivalents in FIGS. 2A-4E) appear to be formed in openings in insulation layers *above* the insulation layer in which metal line 103 is formed, it does not appear possible for Sekiguchi to enable one to make an alloy layer on a metal line in a via in an insulating layer that is coplanar with or lower than a top surface of the insulation layer (see Claim 1 above). As a result, the present claims (including Claims 24-25 and 32) are patentable over Sekiguchi.

Thus, the rejection of Claims 24-25 and 32 under 35 U.S.C. § 103(a) is not sustainable and should be withdrawn.

The Rejection of Claims 5, 8, 21-22, 31 and 34 under 35 U.S.C. § 103(a)

The rejection of Claims 5, 8, 21-22, 31 and 34 under 35 U.S.C. § 103(a) as being unpatentable over Sekiguchi in view of Liu et al. (US 6,638,867, hereinafter "Liu") is respectfully traversed.

As discussed above, Sekiguchi fails to teach, disclose or suggest an alloy layer on a metal line in a via in an insulating layer that is coplanar with or lower than a top surface of the insulation layer (see Claim 1 above). Liu fails to cure the deficiency of Sekiguchi with regard to Claim 1.

Liu discloses a bonding pad 60 that includes an aluminum alloy bonding pad segment 54 in a shallow interconnection line 40 (see col. 6, ll. 16-27, and FIGS. 6C-6D) and an aluminum conductive layer 58 over the bonding pad segment 54 (see col. 6, ll. 34-42, and FIG. 6C). Liu further discloses that the conductive layer 58 over the bonding pad segment 54 can alternatively consist of aluminum alloy, tungsten, copper, or a copper alloy (see col. 6, ll. 35-40). Aluminum has a melting point below 1000°C., and as a result, the aluminum alloy conductive layer 58 on bonding pad segment 54 could, in theory, be the claimed alloy. However, Liu does not appear to teach or disclose that the non-aluminum metal in the aluminum alloy is the same as a metal in

Atty. Docket No. OPP030889US/PPW06-563DS
Serial No: 10/676,645

bonding pad segment 54 (see col. 6, ll. 34-40). Similarly, the copper alloy alternative for conductive layer 58 could be the claimed alloy, but there is no indication in Liu that the copper alloy is an alloy of copper and aluminum (see col. 6, ll. 34-40). It is therefore believed that Liu does not disclose an alloy layer comprising both a low melting point metal having a melting point less than or equal to 1000° C and a metal of a metal line, assuming for the sake of argument that bonding pad segment 54 constitutes a metal line.

On the other hand, if one selects aluminum or aluminum alloy for conductive layer 58 and a different metal or alloy for bonding segment 54, bonding pad segment 54 and conductive layer 58 could, in theory, form the claimed alloy. However, it appears that any such alloy would have a top surface that would not be coplanar with or lower than a top surface of the insulation layer, as recited in Claim 1. In addition, the bonding pad 60 disclosed by Liu includes shallow trench 40 that only partially penetrates insulative layer 134 (see col. 5, ll. 55-64, and FIG. 5A). Therefore, the metal feature 54 in shallow trench 40 is not in a via (see FIGS. 6A-6D). Thus, the bonding pad 60 disclosed by Liu does not cure the deficiency of Sekiguchi with regard to the present Claim 1.

Liu does disclose a metal feature 50 in a via (col. 6, ll. 16-24). However, it is not included in the structure of bonding pad 60, and no metal or metal alloy is on an upper surface thereof. Therefore, Liu does not cure the deficiency of Sekiguchi with regard to the present Claim 1.

As a result, Claim 1 (and all claims dependent therefrom, including Claims 5, 8, 21-22, 31 and 34) are patentable over Sekiguchi in view of Liu, the combination of which fails to teach, disclose or suggest an alloy layer on a metal line in a via in an insulating layer that is coplanar with or lower than a top surface of the insulation layer. Consequently, the rejection of Claims 5, 8, 21-22, 31 and 34 under 35 U.S.C. § 103(a) should be withdrawn.

Atty. Docket No. OPP030889US/PPW06-563DS
Serial No: 10/676,645

The Rejection of Claims 1, 26, 29 and 33 under 35 U.S.C. § 103(a)

The rejection of Claim 7 under 35 U.S.C. § 103(a) as being unpatentable over Grass (U.S. Pat. No. 5,563,099; hereinafter "Grass") is respectfully traversed.

Again, Applicant's undersigned representative notes that neither former Claim 25 nor Claim 26 was a product-by-process claim. To clarify the record, Claim 25 did not recite the term "via" or "forming," although the Office Action indicates that it did (see p. 7, last full paragraph above the title "Response to Arguments"). Claim 26 did recite that "the via is within the insulation layer," but it is not at all clear how one can read a process for forming the via into this limitation. Applicant's undersigned representative agrees that the limitation recited in Claim 26 recites a structure. A structure can be characterized by its location without requiring a process of forming the structure. Grammatically, there is no verb in the recited limitation. It is not understood how one can read a verb (process) into the limitation.

That being said, the Office Action further appears to characterize the disclosure of Grass using the terms recited in the present claims, rather than the terms disclosed by Grass. However, assuming *arguendo* that the characterization of Grass in the Office Action is reasonably accurate, as is recognized in the Office Action, the alloy layer disclosed by Grass does not appear to include a metal of the metal line and a low melting point metal having a melting point less than or equal to 1000°C.

Metal layer 14b of Grass is a thick conductor layer, such as an aluminum alloy that may contain a small amount of copper and silicon, such as around 0.5% copper and around 1% silicon (col. 3, ll. 39-43). Layer 14c of Grass is a thin continuous intermetallic layer (col. 3, ll. 46-47). When layer 14b is an aluminum alloy, intermetallic layer 14c can be formed by metals *that react with aluminum*, such as titanium Ti, zirconium Zr, hafnium Hf, chromium Cr, molybdenum Mo, tungsten W, copper Cu, palladium Pd, platinum Pt, and nickel Ni (col. 3, ll. 50-55; emphasis added). For example, Ti reacts with aluminum to form $TiAl_3$ (col. 3, ll. 39-43). As is known, none of the listed metals that react with aluminum have a melting point less than or equal to 1000°C. (see the CRC Handbook of Chemistry and Physics, 64th ed. [1983], CRC Press, Boca Raton, Florida, inside back cover, submitted herewith). Thus, the alloy layer disclosed by Grass

Atty. Docket No. OPP030889US/PPW06-563DS
Serial No: 10/676,645

does not appear to include a metal of the metal line and a low melting point metal having a melting point less than or equal to 1000°C.

However, it has been asserted (without supporting evidence or reasoning) that substitution of a low melting point metal having a melting point less than or equal to 1000°C. for the metal that reacts with aluminum as disclosed by Grass would be obvious to one of ordinary skill in the art, to improve device properties. The Examiner is again invited to read the Manual of Patent Examining Procedure ("MPEP"), § 2143, which clearly states that there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings, and that the prior art reference (or references when combined) must teach or suggest all the claim limitations. In this case, no reference cited against the present claims provides any suggestion or motivation to substitute an alloy layer comprising (1) a metal of the metal line in an insulator layer and (2) a low melting point metal having a melting point less than or equal to 1000°C., for a different alloy layer that has a top surface that is coplanar with or lower than a top surface of the insulation layer. The only suggestion to do so comes from the present application.

An assertion that one of ordinary skill in the art would modify the disclosures of the cited references in the manner necessary to arrive at the invention, without any suggestion in the references to do so, is a classic hindsight reconstruction of the invention. One cannot use hindsight reconstruction to pick and choose among isolated disclosures in the cited references to deprecate the claimed invention. *In re Fine*, 837 F.2d 1071, 1075, 5 U.S.P.Q.2d 1596, 1600 (Fed. Cir. 1988); see also *In re Pleudemann*, 910 F.2d 823, 828, 15 U.S.P.Q.2d 1738, 1742 (Fed. Cir. 1990); and *Uniroyal, Inc. v. Rudkin-Wiley Corp.*, 837 F.2d 1044, 1051, 5 U.S.P.Q.2d 1434, 1438 (Fed. Cir. 1988). To use the patent [application] as a guide through the cited references, combining the right disclosures in the right way to arrive at the result of the claimed invention, is improper. See, e.g., *Medtronic, Inc. v. Daig Corp.*, 611 F. Supp. 1498, 1534, 227 U.S.P.Q. 509, 535 (D. Minn. 1985), *aff'd* 789 F.2d 903, 229 U.S.P.Q. 664 (Fed. Cir. 1986).

Atty. Docket No. OPP030889US/PPW06-563DS
Serial No: 10/676,645

Consequently, the apparent basis for this ground of rejection is inadequate to establish *prima facie* obviousness of Claim 1. Accordingly, this ground of rejection is unsustainable, and should be withdrawn.

Conclusions

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,



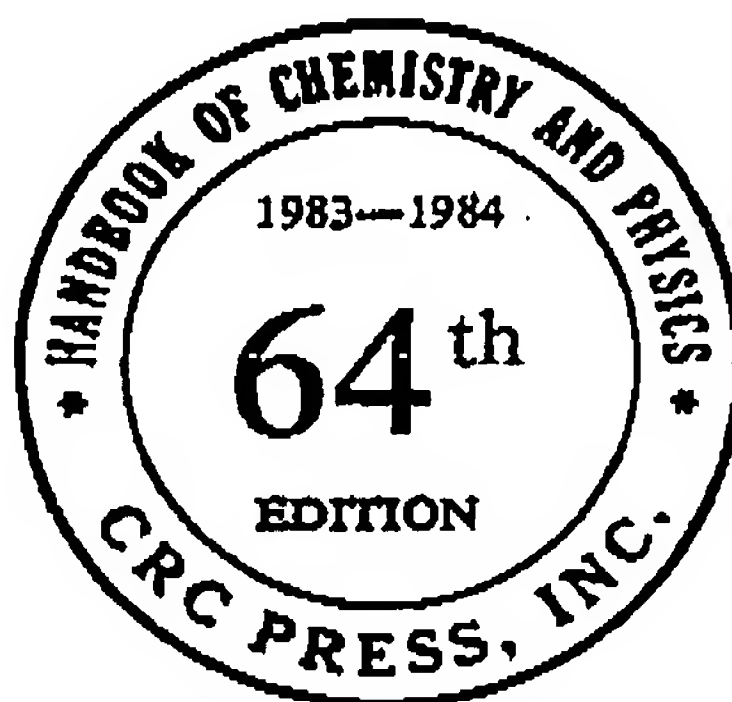
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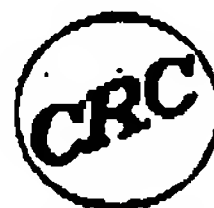
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MELTING AND BOILING POINTS, AND ATOMIC WEIGHTS OF THE ELEMENTS

Based on the Assigned Relative Atomic Mass of $^{12}\text{C} = 12$

The following values apply to elements as they exist in materials of terrestrial origin and to certain artificial elements. When used with the footnotes, they are reliable to ± 1 in the last digit, or ± 3 if that digit is in small type.

Name	Symbol	Atomic number	Atomic weight	Melting point, °C	Boiling point, °C
Actinium ^k	Ac	89	227.028	1,050	3,200 \pm 300
Aluminum	Al	13	26.98154 ^b	660.37	2,467
Americium	Am	95	(243)	994 \pm 4	2,607
Antimony	Sb	51	121.73 ^a	630.74	1,750
Argon ^{h,i}	Ar	18	39.948 ^{a,b,c,d,g}	-189.2	-185.7
Arsenic (gray)	As	33	74.9216 ^a	817(28 atm)	613(sub.)
Astatine	At	85	(210)	302	337
Barium ^l	Ba	56	137.33	725	1,640
Berkelium	Bk	97	(247)	-	-
Beryllium	Be	4	9.01218 ^a	1,278 \pm 5	2,970(5 mm)
Bismuth	Bi	83	208.9804 ^a	271.3	1,560 \pm 5
Boron ^{h,i}	B	5	10.81 ^{a,c,d,e}	2,300	2,550(sub.)
Bromine	Br	35	79.904 ^e	-7.2	58.78
Cadmium ^l	Cd	48	112.41	320.9	765
Calcium ^l	Ca	20	40.08	839 \pm 2	1,484
Californium	Cf	98	(251)	-	-
Carbon ^{h,i}	C	6	12.011 ^{b,d}	3,652(sub)	1
Cerium ^l	Ce	58	140.12	798 \pm 3	3,257
Cesium	Cs	55	132.9054 ^c	28.40 \pm 0.01	669.3
Chlorine	Cl	17	35.453 ^c	-100.98	-34.6
Chromium	Cr	24	51.996 ^e	1,857 \pm 20	2,672
Cobalt	Co	27	58.9332 ^a	1,495	2,870
Copper ^h	Cu	29	63.546 ^{a,c,d}	1,083.4 \pm 0.2	2,567
Curium	Cm	96	(247)	1,340 \pm 40	-
Dysprosium	Dy	66	162.50 ^a	1,409	2,335
Einsteinium	Es	99	(254)	-	-
Erbium	Er	68	167.26 ^a	1,522	2,510
Europium ^l	Eu	63	151.96	822 \pm 5	1,597
Fermium	Fm	100	(257)	-	-
Fluorine	F	9	18.998403 ^a	-219.62	-188.14
Francium	Fr	87	(223)	(27)	(677)
Gadolinium ^l	Gd	64	157.25 ^a	1,311 \pm 1	3,233
Gallium	Ga	31	69.72	29.78	2,403
Germanium	Ge	32	72.59 ^a	937.4	2,830
Gold	Au	79	196.9665 ^a	1,064.43	3,080
Hafnium	Hf	72	178.49 ^a	2,227 \pm 20	4,602
Helium ^l	He	2	4.00260 ^b	-272.2 ^a atm	-268.934
Holmium	Ho	67	164.9304 ^a	1,470	2,720
Hydrogen ^h	H	1	1.0079 ^{b,d}	-252.14	-252.87
Indium ^l	In	49	114.82	156.61	2,080
Iodine	I	53	126.9045 ^a	113.5	184.35
Iridium	Ir	77	192.22 ^a	2,410	4,130
Iron	Fe	26	55.847 ^a	1,535	2,750
Krypton ^l	Kr	36	83.80	-156.6	-152.30 \pm 0.10
Lanthanum ^l	La	57	138.9055 ^{a,b}	920 \pm 5	3,454
Lawrencium	Lr	103	(260)	-	-
Lead ^{h,i}	Pb	82	207.2 ^{a,d}	327.502	1,740
Lithium ^{h,i,j}	Li	3	6.941 ^{a,c,d,e}	180.54	1,342
Lutetium	Lu	71	174.967 \pm 0.003	1,656 \pm 5	3,315
Magnesium ^l	Mg	12	24.305 ^c	648.8 \pm 0.5	1,090
Manganese	Mn	25	54.9380 ^a	1,244 \pm 3	1,962
Mendelevium	Md	101	(257)	-	-
Mercury	Hg	80	200.59 ^a	-38.87	356.58
Molybdenum	Mo	42	95.94	2,617	4,612
Neodymium ^l	Nd	60	144.24 ^a	1,010	3,127
Neon ^h	Ne	10	20.179 ^{a,c}	-248.67	-246.048
Neptunium ^k	Np	93	237.0482 ^b	640 \pm 1	3,902
Nickel	Ni	28	58.70	1,453	2,722
Niobium (Columbium)	Nb	41	92.9064 ^a	2,468 \pm 10	4,742

MELTING AND BOILING POINTS, AND ATOMIC WEIGHTS OF THE ELEMENTS (Continued)

Name	Symbol	Atomic number	Atomic weight	Melting point, °C	Boiling point, °C
Nitrogen	N	7	14.0067 ^{b,c}	-209.86	-195.8
Nobelium	No	102	(259)	-	-
Osmium ^l	Os	76	190.2	3,045 ± 30	5,027 ± 100
Oxygen ^h	O	8	15.9994 ^{a,b,c,d}	-218.4	-182.962
Palladium ^l	Pd	46	106.4	1,554	3,140
Phosphorus	P	15	30.97376	44.1 (white)	280 (white)
Platinum	Pt	78	195.09 ^a	1,772	3,827 ± 100
Plutonium	Pu	94	(244)	641	3,232
Polonium	Po	84	(209)	254	962
Potassium	K	19	39.0983 ^a	63.25	759.9
Praseodymium	Pr	59	140.9077 ^a	931 ± 4	3,212
Promethium	Pm	61	(145)	-1,080	2,460(?)
Protactinium ^k	Pa	91	231.0359 ^a	<1,600	-
Radium ^{l,k}	Ra	88	226.0254 ^{a,f,g}	700	1,140
Radon	Rn	86	(222)	-71	-61.8
Rhenium	Rc	75	186.2	3,180	5,627 (est.)
Rhodium	Rh	45	102.9055 ^a	1,966 ± 3	3,727 ± 100
Rubidium ^l	Rb	37	85.4678 ^{a,c}	38.89	686
Ruthenium ^l	Ru	44	101.07 ^a	2,310	3,900
Samarium ^l	Sm	62	150.4	1,072 ± 5	1,778
Scandium	Sc	21	44.9559 ^a	1,539	2,832
Selenium	Se	34	78.96 ^a	217	684.9 ± 1.0
Silicon	Si	14	28.0855 ^a	1,410	2,355
Silver ^l	Ag	47	107.8682 ^c	961.93	2,212
Sodium	Na	11	22.98977 ^a	97.81 ± 0.03	882.9
Strontium ^l	Sr	38	87.62 ^a	769	1,384
Sulfur ^h	S	16	32.06 ^d	112.8	444.674
Tantalum	Ta	73	180.9479 ^{a,b}	2,996	5,425 ± 100
Technetium	Tc	43	(97) ^f	2,172	4,877
Tellurium ^l	Te	52	127.60 ^a	449.5 ± 0.3	989.8 ± 3.8
Terbium	Tb	65	158.9254 ^a	1,360 ± 4	3,041
Thallium	Tl	81	204.37 ^a	303.5	1,457 ± 10
Thorium ^{l,k}	Th	90	232.0381 ^a	1,750	~4,790
Thulium	Tm	69	168.9342 ^a	1,545 ± 15	1,727
Tin	Sn	50	118.69 ^a	231.9681	2,270
Titanium	Ti	22	47.90 ^a	1,660 ± 10	3,287
Tungsten	W	74	183.85 ^a	3,410 ± 20	5,660
Uranium ^l	U	92	238.029 ^{b,c,e}	1,132.3 ± 0.8	3,818
Vanadium	V	23	50.9415 ^{a,b,c}	1,890 ± 10	3,380
Wolfram (see Tungsten)					
Xenon ^l	Xe	54	131.30	-111.9	-107.1 ± 3
Ytterbium	Yb	70	173.04 ^a	824 ± 3	1,193
Yttrium	Y	39	88.9059 ^a	1,523 ± 8	3,337
Zinc	Zn	30	65.38	419.58	907
Zirconium ^l	Zr	40	91.22	1,852 ± 2	4,377

^aMononuclidic element.

^bElement with one predominant isotope (about 99 to 100% abundance).

^cElement for which the atomic weight is based on calibrated measurements.

^dElement for which variation in isotopic abundance in terrestrial samples limits the precision of the atomic weight given.

^eElement for which users are cautioned against the possibility of large variations in atomic weight due to inadvertent or undisclosed artificial isotopic separation in commercially available materials.

^fMost commonly available long-lived isotope.

^gIn some geological specimens this element has a highly anomalous isotopic composition, corresponding to an atomic weight significantly different from that given.

^hElement for which known variations in isotopic composition in normal terrestrial material prevent a more precise atomic weight given; $A_r(E)$ values should be applicable to any "normal" material.

ⁱElement for which geological specimens are known in which the element has an anomalous isotopic composition, such that the difference in atomic weight of the element in such specimens from that given in the Table may exceed considerably the implied uncertainty.

^jElement for which substantial variations in A_r from the value given can occur in commercially available material because of inadvertent or undisclosed change of isotopic composition.

^kElement for which the value A_r is that of the radioisotope of longest half-life.

^lTriple points: (graphite-liquid-gas), 3627±50°C at a pressure of 10.1 MPa and (graphite-diamond-liquid), 3820–3930°C at a pressure of 12–13 GPa.